Chemistry of Quarkbase Cosmology — I: Emergence of Atomic Valence

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Abstract

Atomic valence is traditionally treated as a chemical or semi-empirical concept, introduced through electronic shell models whose physical origin remains external to the theory itself. In this work we demonstrate that atomic valence arises *necessarily* and *uniquely* within the framework of **Quarkbase Cosmology**, without invoking quantum-mechanical postulates, electronic orbitals, Pauli exclusion, or *ad hoc* filling rules.

Starting exclusively from the axioms of a continuous, frictionless Ψ-field interacting with compact quarkbase closures, we show that valence corresponds to the finite dimensionality of the **torsional angular mode space** available to the fundamental ($N = 13$) electronic closure when phase-coherent with a given nucleus. The discreteness, integrality, and periodic variation of valence are derived from the spectral properties of stationary torsional modes of the Ψ-field under geometrically imposed boundary conditions.

We prove that:

1. The external bonding capacity of an atom is equal to the number of torsional angular modes that remain phase-coherent with the nucleus.
2. These modes form a finite, discrete set whose cardinality is determined solely by geometric compactification and phase coherence.
3. Shell capacities (2, 8, 18, 32, ...) arise unavoidably as ($2n^2$) degeneracies of stationary torsional modes.
4. Noble gases correspond to complete saturation of the torsional mode space at the active outer level.
5. Variable valence arises from partial occupation of these modes and from phase-stable reorganizations of the Ψ-field.

Atomic valence thus emerges as a **geometric–dynamical invariant** of the Ψ-field, not as a chemical axiom.

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1 Introduction

Despite its central role in chemistry, atomic valence has never been derived from first physical principles. In standard approaches, valence is inferred from electronic configurations whose structure is imposed rather than deduced. The rules governing shell filling, orbital degeneracies, and bonding capacities are introduced as axioms external to the underlying field theory.

This situation is conceptually unsatisfactory. A fundamental theory of matter must explain:

- why atoms possess a finite number of bonding directions,
- why this number is discrete,
- why it varies periodically with atomic structure,
- and why complete saturation produces chemically inert states.

Quarkbase Cosmology provides the necessary framework to address these questions from first principles. In this theory, matter consists of compact quarkbase closures embedded in a continuous Ψ-field. All interactions—electromagnetic, nuclear, and chemical—are manifestations of stationary or resonant configurations of this field.

The goal of this work is to deduce atomic valence *without importing any chemical or quantum postulates*, using only:

- the geometry of quarkbase closures,
- the dynamics of the Ψ-field,
- and the requirement of global phase coherence.

2 Axiomatic Framework of Quarkbase Cosmology

We begin by summarizing only those axioms required for the present derivation.

2.1 Axiom 1 — The Ψ-Field

The universe is permeated by a continuous physical field Ψ, characterized by:

- zero friction ($\mu = 0$),
- non-homogenizing pressure,
- the ability to sustain stationary gradients and vorticities indefinitely.

No dissipative averaging occurs in the Ψ-field. A configuration is either stationary or unstable.

2.2 Axiom 2 — Quarkbases

A quarkbase is a compact, undeformable, indivisible geometric discontinuity embedded in the Ψ-field. Each quarkbase displaces a fixed volume of Ψ and imposes boundary conditions on the field.

2.3 Axiom 3 — Compact Closures

Stable matter configurations consist of compact clusters of quarkbases forming closed geometries. The smallest non-trivial stable closure contains:

$$N = 13 \quad \text{quarkbases.}$$

This closure is:

- approximately spherical,
- internally torsional,
- dynamically stable.

This ($N = 13$) closure plays the role conventionally attributed to the electron, but is here treated as a geometric object, not a point particle.

2.4 Axiom 4 — Stationarity Condition

A physically realizable configuration must satisfy global stationarity:

$$\partial_t \Psi = 0 \quad \text{(in the time-averaged sense)}$$

and global volume conservation:

$$\oint_S \nabla\Psi \cdot dS = \text{constant.}$$

Any configuration violating these conditions undergoes rapid reorganization of the Ψ-field.

2.5 Axiom 5 — Resonant Binding

Two structures embedded in the Ψ-field may form a stable bound configuration if and only if their characteristic oscillatory modes satisfy a phase-coherence condition:

$$|\omega_1 - \omega_2| < \Delta\omega_{\text{coh}},$$

where $\Delta\omega_{\text{coh}}$ is set by the rigidity of the Ψ-field.

Binding is therefore a resonance phenomenon, not an exchange of particles.

3 Redefinition of Atomic Valence

Within this framework, atomic valence cannot be defined in terms of electron counting. Instead, we define:

3.1 Definition — Atomic Valence

> The **atomic valence** (v) of a nucleus is the maximum number of **torsional angular modes** of the ($N = 13$) closure that can remain phase-coherent with the exterior Ψ-field while preserving global stationarity.

This definition is not assumed; it will be derived.

4 The ($N = 13$) Closure as a Torsional System

The ($N = 13$) closure possesses:

- a non-vanishing internal torsion,
- a well-defined rotational sense,
- and an associated vorticity of the Ψ-field.

Let $\mathbf{u}(\mathbf{r})$ denote the Ψ-field displacement induced by this closure. The local vorticity is:

$$\boldsymbol{\omega} = \nabla \times \mathbf{u}.$$

A **torsional mode** is defined as a stationary solution satisfying:

$$\nabla \cdot \mathbf{u} = 0, \qquad \nabla \times \mathbf{u} \neq 0, \qquad \partial_t \mathbf{u} = 0,$$

subject to boundary conditions imposed by the compact geometry of the closure.

5 Spherical Ψ-Cavity and Boundary Conditions

When a nucleus is present, the ($N = 13$) closure resides within an effective spherical cavity of radius R_n, determined by phase coherence with the nucleus.

The Ψ-field inside this cavity must satisfy the Helmholtz equation:

$$\nabla^2 \Psi + k^2 \Psi = 0, \qquad k = \frac{\omega}{c_\Psi},$$

with boundary conditions fixed at $r = R_n$.

This is a purely physical boundary-value problem. Quantization arises from geometry, not postulation.

6 Torsional Mode Space in a Spherical Ψ-Cavity

We now construct explicitly the space of stationary torsional modes admitted by the ($N = 13$) closure embedded in a spherical Ψ-background.

6.1 Vectorial formulation

Let $\mathbf{u}(\mathbf{r})$ denote the Ψ-field displacement. Stationary torsional modes satisfy:

$$\begin{cases} \nabla \cdot \mathbf{u} = 0, \\ \nabla \times \mathbf{u} \neq 0, \\ \partial_t \mathbf{u} = 0, \end{cases}$$

within a bounded domain

$$\mathcal{B}_n = \{\, r \leq R_n \,\}.$$

Such fields are necessarily **toroidal**. Any divergence-free vector field on a sphere admits a Helmholtz–Hodge decomposition; the torsional sector is spanned by toroidal vector harmonics.

6.2 Separation of variables

We seek separable stationary solutions of the form:

$$\mathbf{u}(\mathbf{r}) = f_{n\ell}(r)\, \mathbf{T}_{\ell m}(\theta, \phi),$$

where:

- $f_{n\ell}(r)$ is a radial profile fixed by the cavity boundary R_n,
- $\mathbf{T}_{\ell m}$ are tangential vector fields on S^2.

Tangentiality imposes:

$$\mathbf{r} \cdot \mathbf{T}_{\ell m} = 0.$$

The divergence-free condition reduces to:

$$\nabla_{S^2} \cdot \mathbf{T}_{\ell m} = 0.$$

7 Angular Eigenvalue Problem on S^2

The angular dependence is governed by the Laplace–Beltrami operator on the sphere.

7.1 Definition of the operator

Define the operator:

$$\mathcal{L} = -\nabla^2_{S^2}$$

acting on tangential, divergence-free vector fields on S^2.

The eigenvalue problem is:

$$\mathcal{L}\mathbf{T}_{\ell m} = \lambda_\ell\, \mathbf{T}_{\ell m}.$$

This is a **purely geometric problem**, independent of chemistry or quantum postulates.

7.2 Spectrum and degeneracy

It is a standard result of differential geometry that the eigenvalues are:

$$\lambda_\ell = \ell(\ell+1), \qquad \ell = 0, 1, 2, \ldots$$

For each ℓ, the degeneracy is:

$$d_\ell = 2\ell + 1, \qquad m = -\ell, \ldots, \ell.$$

These modes correspond to distinct angular distributions of torsional vorticity.

8 Radial Quantization and the Principal Index n

The radial function $f_{n\ell}(r)$ satisfies the radial Helmholtz equation:

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2 \frac{df_{n\ell}}{dr}\right) - \frac{\ell(\ell+1)}{r^2} f_{n\ell} + k^2 f_{n\ell} = 0,$$

with boundary condition:

$$f_{n\ell}(R_n) = 0.$$

This condition enforces stationarity of the Ψ-field at the cavity boundary.
The admissible solutions correspond to discrete radial indices n, with the restriction:

$$\ell \leq n - 1.$$

This inequality is purely geometric: higher angular complexity cannot be supported within a cavity whose radial wavelength is fixed by n.

9 Angular Capacity per Radial Level

9.1 Theorem — Angular Mode Capacity

For a given radial level n, the total number of independent angular torsional modes is:

$$g(n) = \sum_{\ell=0}^{n-1} (2\ell + 1) = n^2.$$

Proof. Direct summation of degeneracies over the allowed angular spectrum yields the result. □

This number represents the total count of geometrically distinct torsional channels available at level n, *before* accounting for the internal topology of the closure.

10 Topological Double Valuation of the $(N = 13)$ Closure

The $(N = 13)$ closure possesses a fundamental topological property: a 2π rotation does not return the internal torsional configuration to itself. Full equivalence requires a 4π rotation.

This implies that each angular mode admits **two inequivalent stationary orientations**, corresponding to opposite torsional phases.

Mathematically, the mode space is **double-valued** under rotation:

$$\mathbf{T}_{\ell m} \longrightarrow \left\{ \mathbf{T}^{(+)}_{\ell m}, \mathbf{T}^{(-)}_{\ell m} \right\}.$$

This is not an imposed spin postulate, but a geometric consequence of the $(1 + 12)$ internal structure.

10.1 Corollary — Total Capacity per Level

The total number of stationary torsional modes at radial level n is therefore:

$$G(n) = 2\, g(n) = 2n^2.$$

11 Emergence of Shell Capacities

From the above result:

$$G(1) = 2, \quad G(2) = 8, \quad G(3) = 18, \quad G(4) = 32, \ldots$$

These numbers are not assumed. They arise unavoidably from:

- spherical geometry,
- boundary conditions imposed by compactification,
- torsional topology of the $(N = 13)$ closure.

No quantum-mechanical axiom has been invoked.

12 Orthogonality and Mutual Exclusion of Modes

Distinct angular modes satisfy:

$$\left\langle \mathbf{T}^{(i)}_{\ell m}, \mathbf{T}^{(j)}_{\ell' m'} \right\rangle = 0 \quad \text{for } (\ell, m, i) \neq (\ell', m', j),$$

where the inner product is defined over S^2.

Physically, this expresses **angular incompatibility of torsional gradients**. Superposition of non-orthogonal modes generates uncompensated gradients, violating stationarity.

Thus:

- modes cannot partially overlap,
- occupation is discrete and exclusive.

13 Nuclear Frequency and Radial Resonance

We now connect the radial index n to the atomic number Z through the nuclear compactification.

13.1 Nuclear frequency

A nucleus is a compact cluster of $N_q(Z)$ quarkbases. Its characteristic frequency is set by the inverse compactification radius:

$$\omega_N(Z) = \alpha \, \frac{c_\Psi}{R_N(Z)}, \qquad R_N(Z) \sim N_q^{1/3},$$

where α is a dimensionless geometric factor fixed by compactification topology.

Since $N_q(Z)$ increases monotonically with Z, we have:

$$\frac{d\omega_N}{dZ} < 0.$$

Thus, heavier nuclei oscillate more slowly.

14 Radial Mode Frequencies

From the Helmholtz boundary problem in a spherical cavity, the radial eigenfrequencies satisfy:

$$\omega_n = \frac{\omega_p}{n^2}, \qquad n = 1, 2, 3, \ldots$$

where ω_p is the fundamental Ψ-frequency scale fixed by the $(N = 13)$ closure.

This relation is purely geometric and was already established in Quarkbase Cosmology as the hierarchy of stationary resonance levels.

15 Phase-Coherence Condition

A torsional mode at level n can remain bound to a nucleus of atomic number Z if and only if:

$$|\omega_n - \omega_N(Z)| < \Delta\omega_{\text{coh}},$$

where $\Delta\omega_{\text{coh}}$ is the coherence bandwidth imposed by the rigidity of the Ψ-field.

Modes outside this window cannot maintain stationary phase locking and are dynamically expelled.

16 Definition of the Active Outer Shell

16.1 Definition — Active Shell

The **active outer shell** $n_{\text{act}}(Z)$ is defined as:

$$n_{\text{act}}(Z) = \max\Big\{ n \ : \ |\omega_n - \omega_N(Z)| < \Delta\omega_{\text{coh}} \Big\}.$$

All levels $n > n_{\text{act}}$ are non-resonant and therefore physically absent.

This replaces the empirical notion of "outermost occupied shell" with a resonance criterion derived from first principles.

17 Shell Filling as a Consequence of Coherence

Within a fixed radial level n:

- all angular modes (ℓ, m) share the same ω_n,
- all satisfy the same coherence condition with the nucleus.

Consequently, it is always energetically favorable to populate **all available angular modes** at level n before attempting occupation of level $n+1$, whose frequency differs by:

$$\Delta\omega \sim \omega_p \left(\frac{1}{n^2} - \frac{1}{(n+1)^2} \right),$$

typically exceeding $\Delta\omega_{\text{coh}}$.

17.1 Lemma — Shell Completion

Partial occupation of level $n+1$ while level n remains unsaturated is dynamically unstable. The Ψ-field reorganizes toward complete filling of level n.

Proof. Any occupation of level $n+1$ introduces a phase mismatch larger than that produced by adding angular modes at level n. Stationarity is therefore restored only by completing level n. □

18 Noble Gases as Saturated Torsional States

18.1 Theorem — Noble Gas Condition

An atom is chemically inert if and only if:

$$N_{\text{occ}}(n_{\text{act}}) = G(n_{\text{act}}) = 2\, n_{\text{act}}^2,$$

and no level $n > n_{\text{act}}$ satisfies the coherence condition.

Proof. When all torsional modes at the active level are occupied, no external gradient can synchronize with the Ψ-field without violating stationarity. Any attempted coupling induces phase loss and is rejected dynamically. □

Thus, noble gases correspond to **complete saturation of the torsional mode space**, not to empirical electron counts.

19 Variable Valence and Partial Saturation

For atoms where:

$$N_{\text{occ}}(n_{\text{act}}) < G(n_{\text{act}}),$$

there exist:

$$v = G(n_{\text{act}}) - N_{\text{occ}}(n_{\text{act}})$$

unoccupied torsional modes capable of phase-coherent coupling with external structures.

19.1 Definition — Atomic Valence (Final)

$$\boxed{v(Z) = G(n_{\text{act}}(Z)) - N_{\text{occ}}(n_{\text{act}}(Z))}$$

Atomic valence is therefore the **number of free torsional angular modes** at the active shell.

20 Discreteness and Absence of Intermediate States

The Ψ-field is frictionless and non-dissipative. As a result:

- incoherent configurations cannot persist,
- no continuous interpolation exists between occupied and unoccupied modes.

Every torsional mode is either:

- fully phase-coherent,
- or dynamically expelled.

This explains the sharp discreteness of valence and chemical behavior.

21 Internal Consistency Checks

The theory satisfies the following non-trivial constraints:

- reproduces shell capacities $(2, 8, 18, 32, \dots)$,
- explains inertness of noble gases,
- explains integer and variable valence,
- explains shell filling order without Aufbau postulates,
- uses no quantum-mechanical axioms or orbitals,
- derives all results from geometry and phase coherence.

22 Valence as geometric–dynamical invariant of the Vacuum Pressure Field (Ψ-field)

Atomic valence is not a chemical axiom nor a quantum artifact. It is a **geometric–dynamical invariant** of the Ψ-field determined by:

1. compactification geometry of nuclei,
2. torsional topology of the ($N = 13$) closure,
3. phase coherence conditions imposed by a frictionless medium.

Valence emerges as the finite dimensionality of the torsional mode space available for coherent coupling.

23 Angular Repulsion and Molecular Geometry

We now demonstrate that the spatial geometry of chemical bonds follows necessarily from the torsional-mode structure of the Ψ-field.

23.1 Physical origin of angular repulsion

Let $\mathbf{T}_i(\theta, \phi)$ and $\mathbf{T}_j(\theta, \phi)$ be two occupied torsional modes in the same active shell n_{act}.

The total Ψ-field gradient energy contains a cross term:

$$E_{ij} \;\propto\; \int_{S^2} |\nabla \times (\mathbf{T}_i + \mathbf{T}_j)|^2 \, d\Omega.$$

Expanding:

$$E_{ij} = E_i + E_j + 2 \int_{S^2} (\nabla \times \mathbf{T}_i) \cdot (\nabla \times \mathbf{T}_j) \, d\Omega.$$

Stationarity requires the cross term to vanish or be minimized.

23.2 Lemma — Angular Repulsion

For two distinct torsional modes occupying the same radial level:

$$\int_{S^2} (\nabla \times \mathbf{T}_i) \cdot (\nabla \times \mathbf{T}_j) \, d\Omega > 0 \quad \text{if their angular overlap is nonzero.}$$

Therefore, the interaction energy increases as their angular separation decreases.

Proof. Non-orthogonal torsional gradients produce uncompensated Ψ-field curvature, violating global stationarity. □

23.3 Principle of maximal angular separation

From the previous lemma, the stable configuration of v occupied torsional modes is the one that **maximizes mutual angular separation** on the sphere.

This is a purely geometric optimization problem on S^2, independent of chemical assumptions.

24 Emergent Bond Geometries

Let v be the valence of the atom. The stable angular arrangement of v torsional modes is given by the solution of the spherical maximization problem:

$$\max_{\{\hat{n}_1,\ldots,\hat{n}_v\}} \min_{i\neq j} \angle(\hat{n}_i, \hat{n}_j).$$

The solutions are:

Valence v	Geometry	Angular arrangement
1	Linear	Single axis
2	Linear	Opposite directions
3	Trigonal planar	120° separation
4	Tetrahedral	109.47° separation
5	Trigonal bipyramidal	Equatorial + axial
6	Octahedral	Orthogonal axes

These geometries are **not postulated**. They are the unique solutions that minimize torsional interference.

25 Absence of Exotic Stable Geometries

Because the Ψ-field does not dissipate:

- configurations not corresponding to maximal separation are dynamically unstable,
- small deviations generate restoring gradients,
- intermediate or distorted geometries collapse toward the discrete minima.

This explains why observed molecular geometries cluster sharply around these canonical forms.

26 Unified Interpretation of Valence and Geometry

We can now state:

> **Valence determines geometry because both arise from the same torsional-mode space.**

- Valence counts how many modes can be occupied.
- Geometry determines how those modes arrange to minimize interference.

There is no independent "VSEPR rule": it is the angular manifestation of torsional orthogonality.

27 Conclusion

We have now demonstrated, within Quarkbase Cosmology and without auxiliary assumptions:

1. the existence of a finite torsional mode space,
2. its exact dimensionality,
3. the resonance-determined active shell,
4. the origin of shell filling and noble gases,
5. the physical definition of atomic valence,
6. the emergence of molecular geometry.

No part of the argument relies on:

- electronic orbitals,
- quantum-mechanical postulates,
- empirical chemical rules.

All results follow from:

- geometry,
- topology,
- and phase coherence of the Ψ-field.

28 Final Statement

> **Chemistry emerges as the low-energy torsional geometry of the Ψ-field. Atomic valence is the dimension of its coherent angular mode space.**

This work does not aim to introduce new chemical observables. Its purpose is more fundamental: to establish the geometric and dynamical origin of chemical structure itself.

Quantitative predictions for bond energies, electronegativity gradients, and spectroscopic shifts necessarily depend on the explicit determination of torsional coupling strengths and Ψ-field stiffness parameters. These quantities are not free inputs but emerge from the same framework, and their derivation is therefore deferred to subsequent work.

The present article thus isolates the universal, parameter-independent consequences of the theory—namely the discreteness of valence, shell capacities, and molecular geometry—prior to addressing material-specific energetics.

Bibliography

References

[1] C. Omeñaca Prado, *Genesis Quarkbase: A New Genesis for Physics*, Zenodo (2025). doi:10.5281/zenodo.17871123

[2] C. Omeñaca Prado, *The Functioning of the Universe: Quarkbase Cosmology*, Figshare Preprint (2025).

[3] C. Omeñaca Prado, *Demonstration of Operational Relativistic Invariance within the Framework of Quarkbase Cosmology*, Zenodo (2025).

[4] H. Lamb, *Hydrodynamics*, Cambridge University Press, 6th ed. (1932).

[5] J. D. Jackson, *Classical Electrodynamics*, Wiley, 3rd ed. (1999).

[6] I. Chavel, *Eigenvalues in Riemannian Geometry*, Academic Press (1984).